

REPORT ON THE TESTING OF UNVENTED KEROSENE HEATERS
IN A HOUSE IN ORLEANS

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Report On The Testing Of Unvented Kerosene Heaters

In A House In Orleans

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Summary

Consumer & Corporate Affairs Canada tested eight unvented kerosene heaters in the living room and a bedroom of a house in Orleans, Ontario. The fuel consumption rate, room temperatures, heater surface temperatures, and levels of oxides of nitrogen (NO_x), carbon monoxide and carbon dioxide produced were measured for each heater.

Each kerosene heater consumed fuel at a constant rate during a run although different fuel consumption rates were observed for separate testing conditions. Kerosene heaters were tested in the bedroom under the following conditions (i) both window and door closed, (ii) window open and door closed, and (iii) window closed and door open. The levels of the three combustion gases and room temperatures were highest in the bedroom with both window and door closed where, after one hour, the ranges of gas concentrations were as follows: NO_x (0 - 5.7 ppm), carbon monoxide (3.1 - 40.1 ppm) and carbon dioxide (1.2 - 2.1 %). Room temperatures attained during the closed bedroom tests ranged from 32 - 62°C. With either window or door open, the maximum gas concentrations attained by the heaters after one hour of testing were NO_x (2.3 ppm), carbon monoxide (13.9 ppm) and carbon dioxide (1.1 %) and temperatures were generally lower than in the closed door/window tests ranging from 30 - 56°C. Tests in the living room resulted in lower gas levels and room temperatures than any of the tests in the bedroom. After three hours testing, the maximum gas levels attained in the living room were NO_x (0.9 ppm), carbon monoxide (10.4 ppm), and carbon dioxide (0.8 %).

These tests show that adequate ventilation is necessary to prevent build-up of carbon monoxide, carbon dioxide and oxides of nitrogen when the heaters are used.

The thermocouple measurements paralleled the Consumers' Association of Canada¹ results with respect to the surface temperatures of the heaters. In the living room experiments where room temperatures did not exceed 32°C, every heater top surface exceeded 200°C and several were in excess of 300°C, the hottest being 350°C. The fronts of the heaters did not reach the same high temperatures but a reading of 78°C was obtained for one heater.

1. "Safety Evaluation: Unvented Kerosene Heaters", Report by the Consumers' Association of Canada to Consumer and Corporate Affairs Canada, 1983.

Introduction

The Consumers' Association of Canada (CAC) was contracted by Consumer and Corporate Affairs Canada (CCAC) to study kerosene heater performance in areas such as stability, surface temperatures and emission levels of combustion products. The CAC study monitored the levels of carbon monoxide, carbon dioxide and oxides of nitrogen (NO_x) emitted by twelve heaters in a controlled environment chamber. A few additional tests were carried out in a home located in Greely, Ontario with two of these heaters and the levels of the combustion gases were found to be markedly lower than those measured during chamber tests.

A second in-house study was initiated by CCAC to expand upon the house tests done by CAC. During this study more unvented kerosene heaters were tested and increased monitoring of gas concentrations was carried out in rooms remote from the one in which the heater was located. Four radiant and four convective type kerosene heaters were tested including the two previously studied in the home in Greely as well as two others from the CAC study. A list of the eight heater brands, types and sizes appears in Appendix A.

Experimental

The test site was a detached, two storey house that had three bedrooms on the second floor with an air exchange rate, as reported by the National Research Council, of 0.2 to 0.3 per hour. The nominal rating for the insulation was R-20 for all exterior walls and R-32 for the ceilings. The windows were triple glazed, wood frame, and nominal R-3. The floor plans and the location of the heaters during the tests are depicted in Figure 1.

Each heater was tested in the smallest bedroom (2.6 x 2.9 x 2.3 m high; 17 m³ volume) and the living room (2.7 x 8.0 x 2.4 m high; 52 m³ volume). However, the effective volume of the living room was considerably larger since it was connected by open doorways to the kitchen, the ground floor halls and the stairwell. With the exception of two heaters that were tested in the living room with the furnace fan running, all heaters were tested with the furnace fan turned off and, except when the protocol called for an open bedroom window, the house was kept closed. During the tests with the bedroom window open the opening provided by the casement window was approximately 400 cm². During the tests fuel consumption rates, temperatures at various locations on the heater and in the room, and the concentrations of carbon monoxide, carbon dioxide, oxygen and NO_x were monitored.

Kerosene heaters were located in the outside corner of the bedroom 0.5 m from the wall and tested under each of the following three conditions:

- (i) both window and door closed,
- (ii) window open 2.5 cm and door closed, and
- (iii) window closed and door open 5.0 cm.

Temperatures were monitored by 30 gauge K-type thermocouples (ungrounded and unshielded) placed at four locations in the bedroom:

- (i) on the gas sampling tube placed at a distance of 1.0 m from the front of the heater and 1.5 m above the floor,
- (ii) on the bedroom wall furthest from the heater, 1.0 m above the floor,
- (iii) on the front of the heater, and
- (iv) on the top surface of the heater.

Testing in the living room consisted of placing the kerosene heater in the middle of the room, 0.5 m from the front window and monitoring the burning of the heater. Again, thermocouples were placed at various locations:

- (i) on the gas sample tube located at a distance of 2.0 m from the front of the heater and 1.5 m off the floor,
- (ii) at the far end of the dining room,
- (iii) on the top surface of the heater,
- (iv) on the front of the heater,

Figure 2 depicts the gas sampling system which was located in the dining area of the combined living room/dining room. Room air was sampled by means of a tube, a pump, and a control panel that channeled room air to the analyzers. In addition to analyzing the air in the test room, gas levels in the other rooms were measured in some of the test runs by taking the gas sampling tube to these rooms (remote sampling). Approximately fifteen seconds was required for the sampling tube to clear and be sampling air representative of the new location. After remote sampling, the tube was returned to the test room. Concentrations of the combustion gases were obtained by using:

- (i) Beckman Model 955 NO/NO_x Analyzer,
- (ii) Beckman Model 865 Carbon Monoxide Infrared Analyzer, and
- (iii) Beckman Model 865 Carbon Dioxide Infrared Analyzer.

A Scott Model 250 Oxygen Analyzer was used to monitor the oxygen content in the test room. The NO/NO_x Analyzer was used in the NO_x mode so that the combined concentrations of nitric oxide (NO) and nitrogen dioxide (NO₂) were measured. The gas analyzers were calibrated before and after the test run in order to account for any instrumental drift. Calibration of the various gas analyzers was accomplished by using the following span gases and instrument scale settings:

- (i) 49.3 ppm NO in N₂, 0-100 ppm scale;
- (ii) 71.3 ppm CO in N₂, 0-100 ppm scale;
- (iii) 2.54 % CO₂ in N₂, 0-2.5% scale;
- (iv) 20.9% O₂ in N₂, 0-25% scale;
- (v) N₂ Zero gas

Voltages associated with zero gas and span gas concentrations for each analyzer were recorded manually and by a data acquisition system. Once calibration of each analyzer was completed, the gas sampling system was switched on and background levels were measured before the kerosene heater was ignited.

The data acquisition system (DAS) consisted of an Apple II Plus microcomputer and a Fluke 7600A Scanner/Multimeter combination with floppy disk drives. The computer software acquired voltage outputs from the gas analyzers and the thermocouples during the experiments and stored this data on floppy disks. The software also accepted messages to indicate events such as the time of ignition and when sampling was being carried out in remote locations. Each voltage output was read four times and the average was stored. The frequency with which outputs were recorded varied from once every ten seconds during calibration to once every minute during the test run. An average of four readings was adequate for thermocouple, carbon monoxide and carbon dioxide data but it was insufficient for the NO_x and oxygen analyzers since these instruments were relatively noisy. Unfortunately, the number of readings could not be increased due to the timing requirements of the software program that ran the DAS.

It was necessary to calibrate and run the NO/NO_x gas analyzer on the 0-100 ppm range since the only available calibration gas was 49.3 ppm nitric oxide. In theory, the analyzer has a linear response over the entire concentration range and this was generally borne out by the experimental results. Examination of the plots of gas concentrations versus time shows that the NO/NO_x analyzer was functioning properly since the NO_x concentration changes mirrored those of carbon monoxide and carbon dioxide when remote sampling was carried out or the door was opened to lower gas concentrations in the room. However, successive readings from the NO/NO_x analyzer were more variable than those from either the carbon dioxide or the carbon monoxide analyzer and consequently, they were less precise. At levels less than 0.2 ppm NO_x it was difficult to determine the exact value for the concentration. If a calibration gas with a lower concentration had been available this problem may have been eliminated.

Appropriate computer software was used to process the raw data. Linear equations were used to convert output voltages from the gas analyzers into the respective gas concentrations, assuming a linear instrument drift from the first to the second calibration. A thermocouple algorithm was employed to convert the associated voltages to temperature readings. Plotting of the gas concentration and temperature graphs was accomplished with a Digital MINC 11/23 Minicomputer and a Houston Instrument COMLOT Model CPS-20 Plotter.

Water-clear kerosene fuel was used in all these tests. The kerosene was analyzed by the Petroleum and Gas Laboratories, CANMET, of Energy, Mines and Resources Canada (Table VIII).

During the experiments the kerosene heater was placed on a weighing scale (Toledo, model 8132 digital balance) so that the mass loss experienced by the heater during the run could be measured. These data were used to calculate fuel consumption rates.

Results and Discussion

The current study was undertaken to expand upon the preliminary data that had been obtained during the CAC study on emission levels from unvented kerosene heaters in a house. The selection of heaters included the two that had previously been tested in the CAC house (heaters 1 and 11) and two other heaters from the CAC study (heaters 6 and 7). Each of these four heaters had been a relatively high emitter of either carbon monoxide or NO_x during chamber tests carried out by CAC. Three new heaters and one slightly used heater were also included in this study. Heater 13 was chosen to represent higher Btu output heaters and heater 15 was selected to compare repeatability with heater 7. Although kerosene heaters with a rated output greater than 15 000 Btu are not recommended for residential use, heater 16 was studied since it is available on the market and there is a possibility that it could be used in a home. Heater 14 had previously been operated for several hours over a period of several days in our Laboratory.

The gas sampling system was located in the dining room area of the combined living room/dining room and the gas analyzers were left on 24 hours a day since they required thermal stability for accurate measurements. There was no indication that the presence of the gas handling system had any effect on the experiments in the bedroom but the heat loss from the gas analyzers did raise the temperature of the dining area. During the experiments where the heater was in the living room, the area in which the gas sampling system was located was generally 2 - 4°C warmer than the temperature of the living room. If the gas analyzers had been located elsewhere, room temperatures in the living room would likely have been lower than the measured values.

The temperature and gas concentration data for experiments in the bedroom after one to two hours are presented in Tables I (a), (b) and (c) while the corresponding results for the living room tests after three hours are given in Table II. The temperature in the living room and gas concentrations in all rooms are tabulated in Table III for elapsed times of one, two and three hours. The results obtained for two heaters that were run in the living room with the furnace fan off in one case and on in the other are given in Table IV. Some representative plots of gas concentrations versus time are presented in Figures 3 to 8 and symbols indicating events that occurred during the run are explained on page 13. The fuel consumption data for each heater is tabulated in Tables VII (a) to (h) and representative plots of fuel consumption versus time appear in Figures 11 and 12.

As noted on each table of gas concentrations, background gas levels were subtracted from the measured values so that the contribution of the heater could be determined. Some background levels were above normal because the experiment had to be initiated before the house was completely aired. The ranges of the background levels are presented in Table V.

An examination of the data reveals, not unexpectedly, that the highest concentrations of emission products in the bedroom occurred when the door and window were closed. For example, after one hour in the closed bedroom, heaters 1 and 7 generated concentrations of 40.1 and 35.8 ppm carbon monoxide, respectively, and heaters 11 and 16 produced levels of 3.1 and 5.7 ppm NO_x , respectively. When either the door was opened 5.0 cm or the window 2.5 cm all the gas concentrations were markedly lower and the temperatures marginally lower than those observed when both the door and window were closed. By comparison, after one hour in the bedroom with the window open 2.5 cm or the door open 5.0 cm heater 1 produced levels of 13.9 and 9.3 ppm carbon monoxide, respectively, and heater 11 generated levels of 1.8 and 1.5 ppm NO_x . Similar decreases in gas concentrations were observed with the other heaters. Opening the door 5.0 cm permitted the gases to migrate to the other bedrooms, albeit at slightly lower concentrations. However, there was essentially no increase in the concentration of these combustion gases on the ground floor.

Figures 3 and 5 are plots of gas concentrations in the bedroom versus time when the door and window were closed. The vertical scale for each gas concentration appears at the top right corner of the plot: NO_x , 0-10 ppm; carbon monoxide, 0-100 ppm; carbon dioxide, 0-2.5%; and oxygen 0-25%. These plots and the other plots of gas concentrations versus time are not corrected for background levels. Figure 3 clearly indicates the degree of noise associated with the oxygen concentration measurements but a trend to lower oxygen concentrations as the run progresses can be ascertained. This behavior was observed in other closed bedroom tests but not when the door or window was open. The decrease in oxygen concentration was estimated to be from 0.5 to 1.5% and the oxygen level quickly went back to normal when the door was opened. Figures 3 and 5 indicate that a steady-state level for combustion gases was approached shortly after two hours when the bedroom was closed.

Figure 5 also illustrates the rapid drop in gas concentrations when the heater was turned off and the door was opened 5.0 cm. Opening and closing the door to turn off the heater undoubtedly contributed to the decay in gas levels but the major cause of the decline in concentrations was leaving the door ajar. In other experiments where the door was fully opened the decrease in gas concentrations was more rapid. Figure 9 shows that the room temperature also decreased quickly when the heater was turned off and the door opened 5.0 cm. Figure 10 is a plot of temperature versus time for the same heater in the bedroom with the window closed and the door open 5.0 cm. The ragged appearance of the temperature plots was likely due to normal oscillations in room temperature caused by convection currents generated by the heater.

Figures 5 and 6 offer a comparison of gas concentrations produced by the same heater during a closed bedroom and an open door experiment. Notable features of the latter experiment include lower concentrations of combustion products and the attainment of a steady-state in pollutant levels after approximately 30 minutes. Remote sampling (Figure 6) showed that the other rooms, particularly on the ground floor, had lower concentrations of the combustion gases. When the heater was turned off the gas levels decreased as the bedroom re-equilibrated with the rest of the house.

Figure 7 illustrates the performance of heater 11 in the bedroom with the door closed but the window open 2.5 cm. The gas concentrations were lower in this experiment than when the room was closed and, although it may appear at first glance that NO_x levels were higher than carbon monoxide, this was not the case since the NO_x scale is one tenth the other. The plot shows that a steady-state was reached in about 40 minutes but that variations in gas levels occurred with time. These changes were probably generated by different wind velocities altering air exchange rates between the room and the exterior. Similar behavior was observed in other open window experiments.

The gas concentrations measured in the living room are given in Tables II and III for the runs made in the living room. As expected, the combustion gas levels were lower in the living room than those generated by the same heater in the bedroom after a comparable period of time. Remote sampling showed that the gases were uniformly distributed throughout the first and second floors, which is not surprising given open bedroom doors and the open nature of the first floor. The maximum gas concentrations measured during the living room tests were 1.1 ppm NO_x , 12.0 ppm carbon monoxide and 0.9 ppm carbon dioxide. Representative plots of gas levels versus time for tests run in the living room appear in Figures 4 and 8. These graphs also show that it required three hours, or more, for the combustion gas concentrations to approach a steady-state in the living room.

The experiments in Orleans were carried out during the last week in April and the first two weeks of May. Most of the tests were run with outdoor temperatures in the range of 5 - 10°C but during one experiment it reached 18°C outside. Temperatures during Canadian winters are generally much colder in most parts of the country than those experienced during the tests. Lower outdoor temperatures would have had an impact on room temperatures in the experiments, particularly those run in the bedroom with the window open. This is an important consideration since the room temperature generally governs the decision to use the kerosene heater. However, it is impossible to accurately calculate room temperatures for exterior temperatures of - 25 or - 35°C because of the large number of variables and the assumptions that are necessary.

In considering the data, it was assumed that the upper limit of the comfort range is 28°C and that most people would shut off their heater when room temperature exceeded this value. The times at which room temperature reached 28°C and the corresponding combustion gas concentrations for each test are given in Table VI. The time required to reach 28°C was relatively short for the bedroom tests; the maximum time was 35 minutes for heater 6 and the next longest time was 32 minutes for heater 7. By 32 minutes heater 7 had generated a gas concentration of 9.1 ppm carbon monoxide but no detectable NO_x . Heater 6, on the other hand, had generated gas levels of 6.0 ppm carbon monoxide and 1.0 ppm NO_x after 35 minutes, and during the next 90 minutes the room temperature increased by only 4°C, to 32°C, while the NO_x level remained at 1.0 ppm.

During the living room tests, room temperatures were augmented by the presence of an additional heat source, the gas sampling system. Therefore, the length of time for room temperature to reach 28°C is shorter for each heater than it would have been in the absence of the gas sampling system. None the

less, several heaters did not raise the living room temperature to 28°C after three hours of operation. The most notable of these is heater 11 which generated a NO_x level of 0.5 ppm at the end of two hours and 0.9 ppm after three hours. Under these conditions, occupants of the house would have been exposed to NO_x concentrations greater than 0.5 ppm for more than an hour, no matter where they were on the ground and second floors. It was observed qualitatively that the temperatures in the bedrooms were noticeably cooler than the living room. Consequently, it is possible that a temperature above 28°C might be tolerated in the living room so that more heat could be transmitted to the other rooms. If such were the case, the time of exposure to NO_x concentrations above 0.5 ppm would be even longer.

Study of Tables IX (a) to (d) reveals that the temperature of the top surface of every heater exceeded 200°C during operation and, in several cases, it was greater than 300°C. The maximum temperature recorded for a top surface was 370°C for heater 13 in the bedroom with the window open and door closed. In this case, the room temperature was 57°C but in the living room tests, where the room temperature did not exceed 27°C, the top surface of heater 11 reached 350°C. The temperature of the top surface of heater 13 during the living room experiment was not available. The top surface was readily accessible on each heater and contact could easily be made with the hot surface. Even the fronts of some heaters became significantly hotter than room temperature. The range of temperatures of heater fronts was 35 - 78°C when the heaters were located in the living room.

The room temperatures reported in Tables I - IV and VI were measured by the thermocouple that was located near the sampling tube 1.5 m above the floor. These values compared favorably with a thermometer hung at the same location and another thermocouple located on the wall approximately 1.0 m off the floor. In some experiments with the convective type heaters, the temperature of the front of the heater had a lower value than that recorded for "room temperature". This was likely a manifestation of the normal temperature stratification that occurs in a room, coupled with the mode of operation of this type of heater where cool air is drawn in at the bottom.

The experimental results serve to highlight a characteristic of kerosene heaters that was observed during the CAC chamber tests - it is difficult to duplicate the same heater performance in replicate tests. Factors affecting heater performance include variations in heater efficiency and the inability of the operator to make identical adjustments to the wick from run to run. Both heaters 7 and 15 were the same model but heater 7 consumed less fuel while producing higher concentrations of carbon monoxide and lower levels of carbon dioxide. In addition, the surface temperatures on heater 7 were generally lower than those measured on heater 15. Since heater 15 consistently generated more heat output than heater 7 it is likely that the differences were due to variations in the heaters and not the wick adjustments made by the operator. On the other hand, heater 6 generated approximately the same temperature profile in the closed bedroom as when the door was open. Plots of the temperature versus time for these two experiments are shown in Figures 9 and 10. The different behavior in this instance would appear to be due to a different wick adjustment.

During the experiments the mass of the heater was measured in order that kerosene consumption rates could be determined. These data are given in Tables VII (a) to (h) and representative graphs of fuel consumption versus time are presented in Figures 11 and 12. The four tests for each heater are plotted on the same graph but the points were not connected to avoid confusion. The kerosene fuel was analyzed by the Petroleum and Gas Laboratories, CANMET of Energy, Mines and Resources Canada and the results are given in Table VIII. It was decided to monitor fuel consumption because of the possibility that the heaters might consume less fuel in situations where concentrations of combustion products became elevated and oxygen concentrations were depleted. The fuel consumption rates were mostly linear but non-zero intercepts occurred because initial fuel consumption was either high or low until the wick was adjusted by the operator. In the closed bedroom tests the fuel consumption rate was generally lower. There appeared to be a trend to lower rates of fuel consumption and, as noted earlier, lower oxygen concentrations at the longer run times but the experiments were terminated before this was confirmed.

Conclusions

Assuming that people would shut off the kerosene heater when room temperature reached 28°C, most heaters did not run long enough to produce levels of NO_x above 0.5 ppm or carbon monoxide above 12 ppm. This was particularly true when the room was large, or a door or window was open to allow increased air circulation. However, outdoor temperatures during these tests were not representative of severe winter conditions often encountered in Canada. Colder temperatures would probably have required longer operating times for the heaters to bring room temperatures to 28°C and possibly have led to higher combustion gas concentrations.

The experiments showed that two heaters produced NO_x levels in excess of 0.5 ppm under conditions that can be considered representative of actual use. These levels were maintained for more than an hour and room temperature did not exceed 28°C in one case, and 32°C in the other.

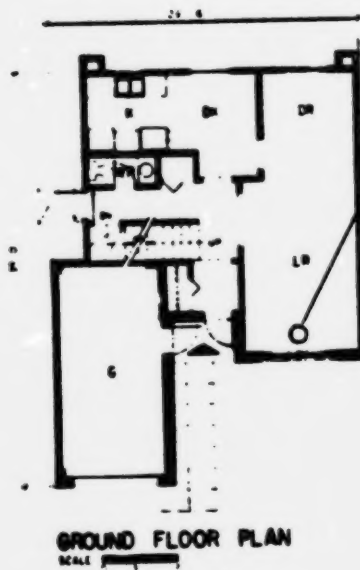
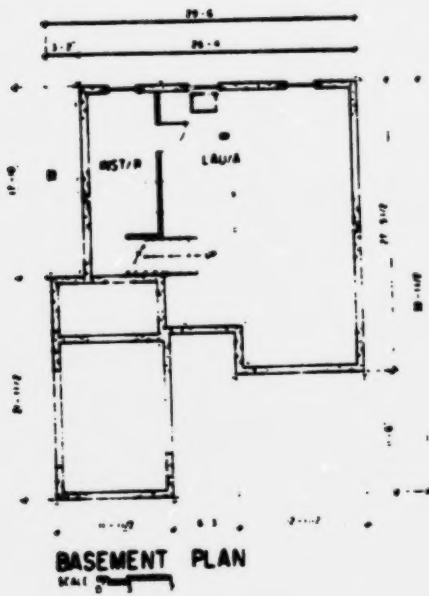
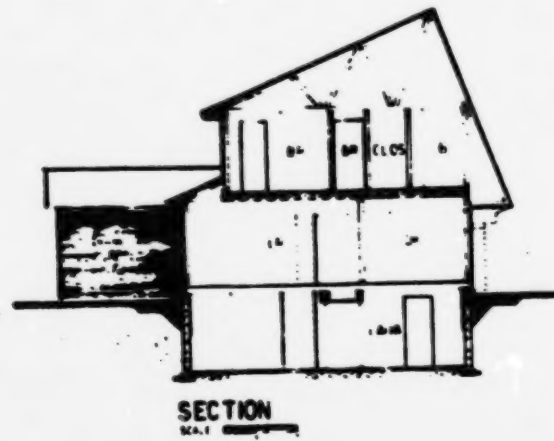
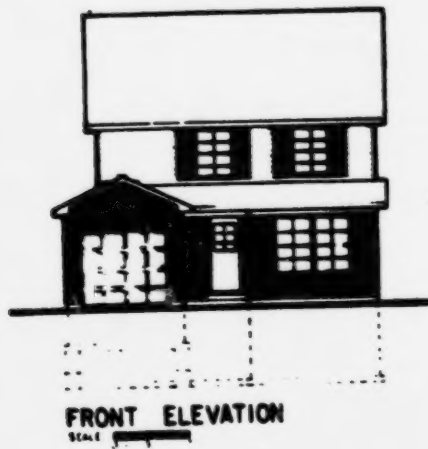
Measurement showed that the top surface of each heater exceeded 200°C, and even 300°C in some cases. This surface was exposed and directly accessible. The use of a protective grill would help lessen the accessibility of the top surface.

Recommendations

Further experiments should be conducted in the Orleans house or a similar house during the winter months so that measurements can be made with exterior temperatures at - 25°C or lower. Additionally, experiments should be carried out in a room equivalent in volume to the master bedroom or perhaps even the living room, i.e., 35-50 m³. The experiments should monitor other gases or vapours such as sulfur dioxide and hydrocarbons. The NO_x analyzer should be calibrated for the 0-10 ppm or the 0-25 ppm range should the former prove to be too noisy. Also, efforts should be made to measure concentrations of both nitric oxide and nitrogen dioxide.

Acknowledgements

We wish to thank the Division of Building Research, National Research Council of Canada for allowing us the use of their house testing facility and the Petroleum and Gas Laboratories, CANMET, of Energy, Mines and Resources Canada for analyzing the kerosene fuel.



HEATER LOCATIONS

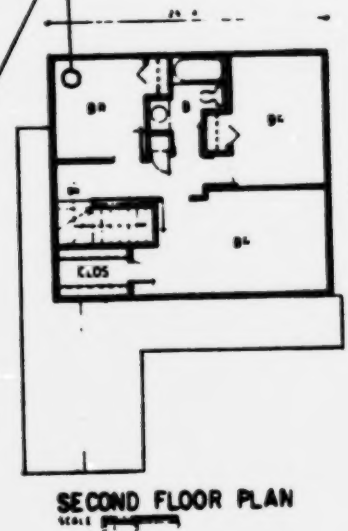


FIGURE 1 Floor Plans of House in Orleans

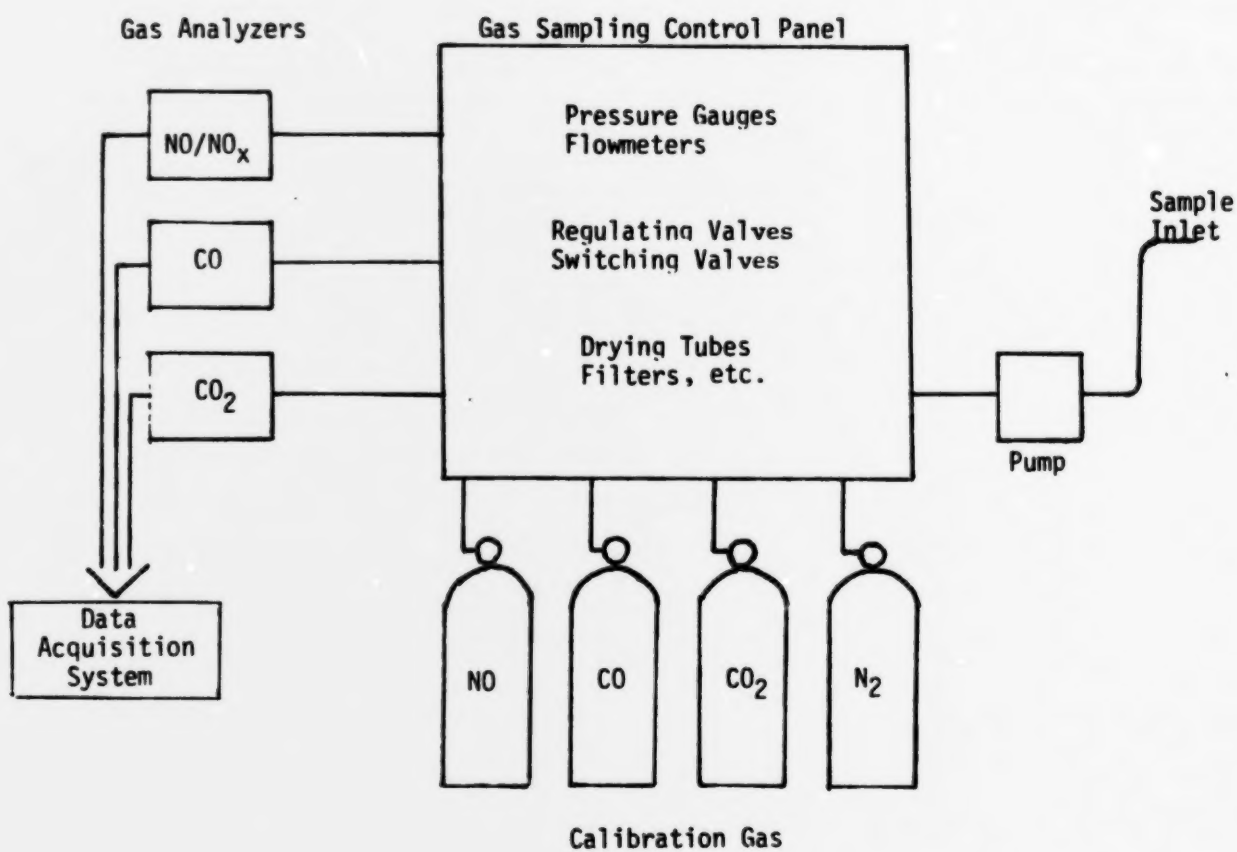


FIGURE 2

GAS SAMPLING SYSTEM

Key to Notation on Plots of Gas Concentrations versus Time

D2 - Bedroom Door Open 2" (5.0 cm)

DW - Bedroom Door Open Wide

RS - Remote Sampling

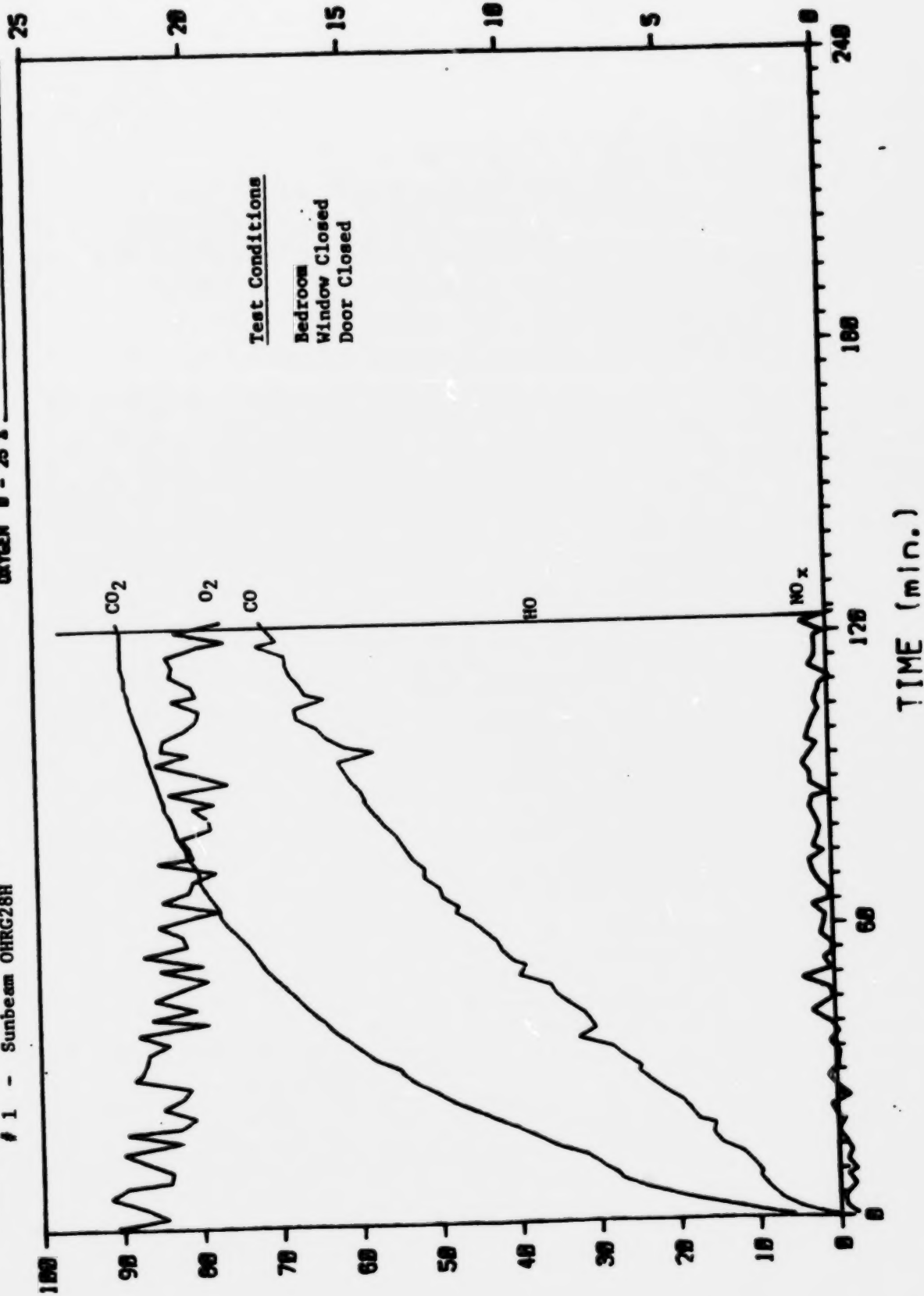
H0 - Heater Off

H1A28.1110

1 - Sunbeam OHRG28H

FIGURE 3

NO_x 0 - 10 ppm
 CARBON MONOXIDE 0 - 100 ppm
 CARBON DIOXIDE 0 - 2.5 %
 OXYGEN 0 - 25 %



Wb: 0 - 10 ppm
Oxygen Humidity 0 - 100 ppm
Carbon Dioxide 0 - 2.5 %
Nitrogen 0 - 25 %

H1M10.110

FIGURE 4

1 - Sunbeam OHRG28H

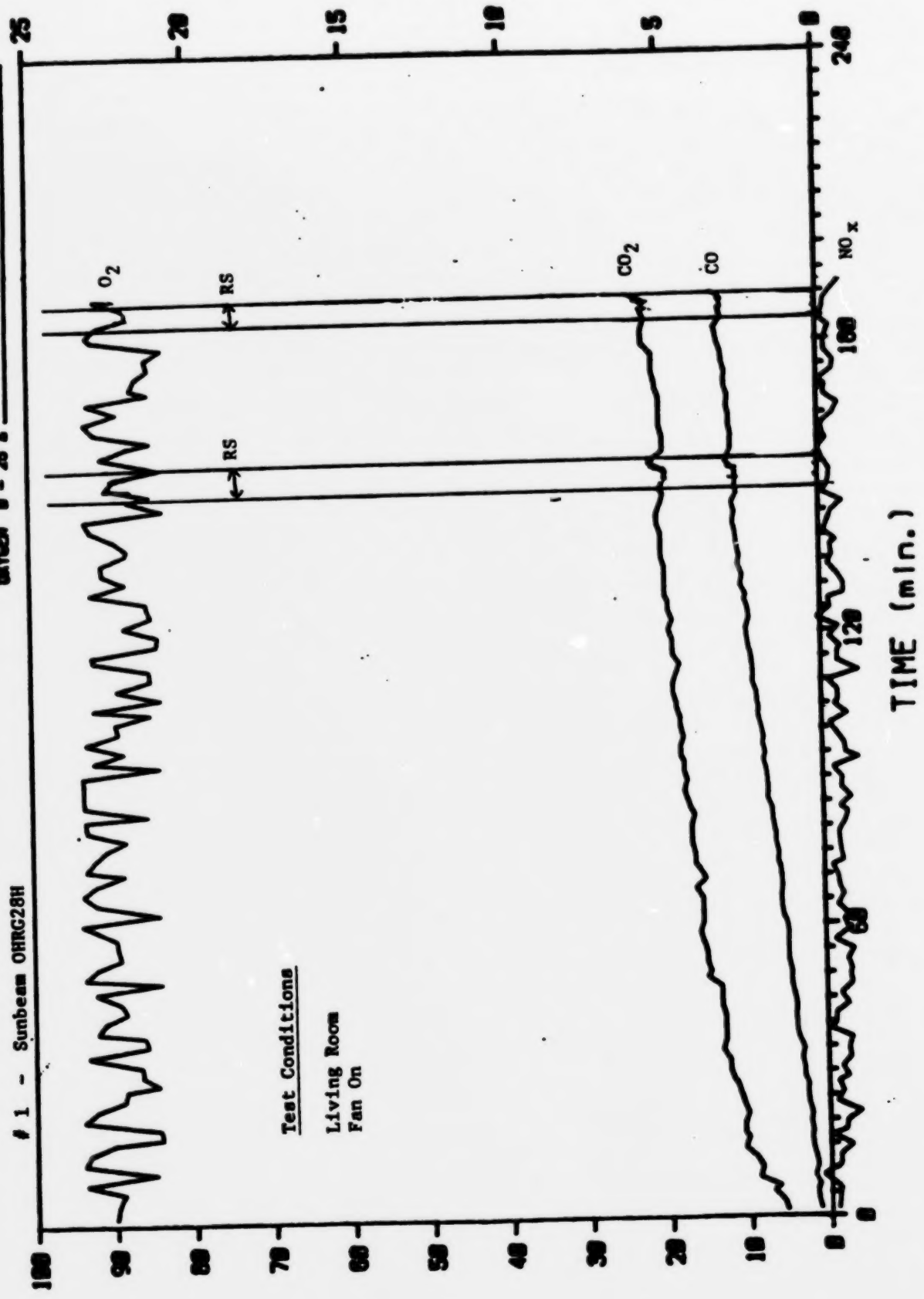


FIGURE 5

H6M8C.110

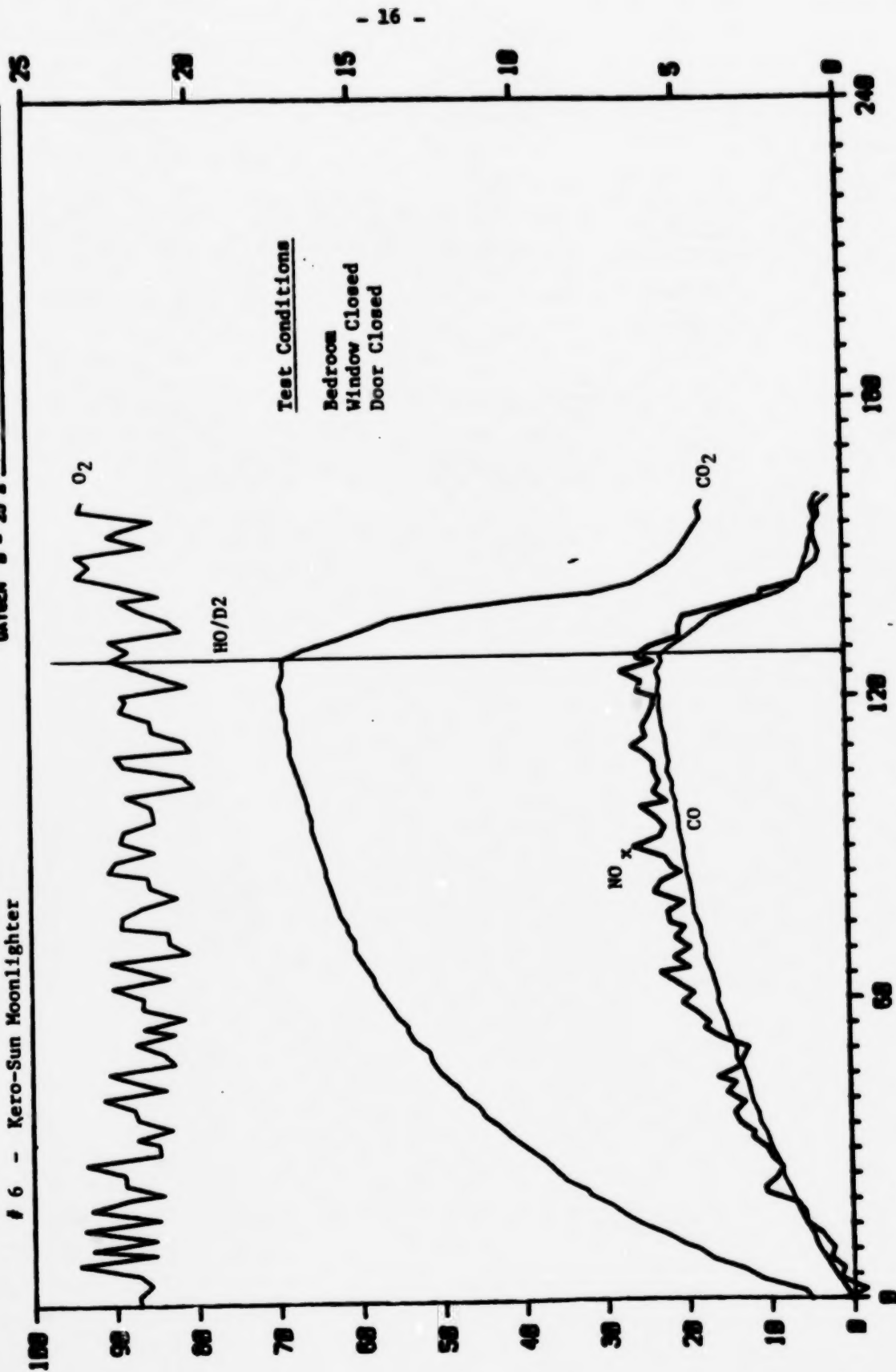
6 - Kero-Sun Moonlighter

NO_x 0 - 10 ppm

OXYGEN 0 - 100 ppm

CARBON DIOXIDE 0 - 2.5 %

HYDROGEN 0 - 25 %

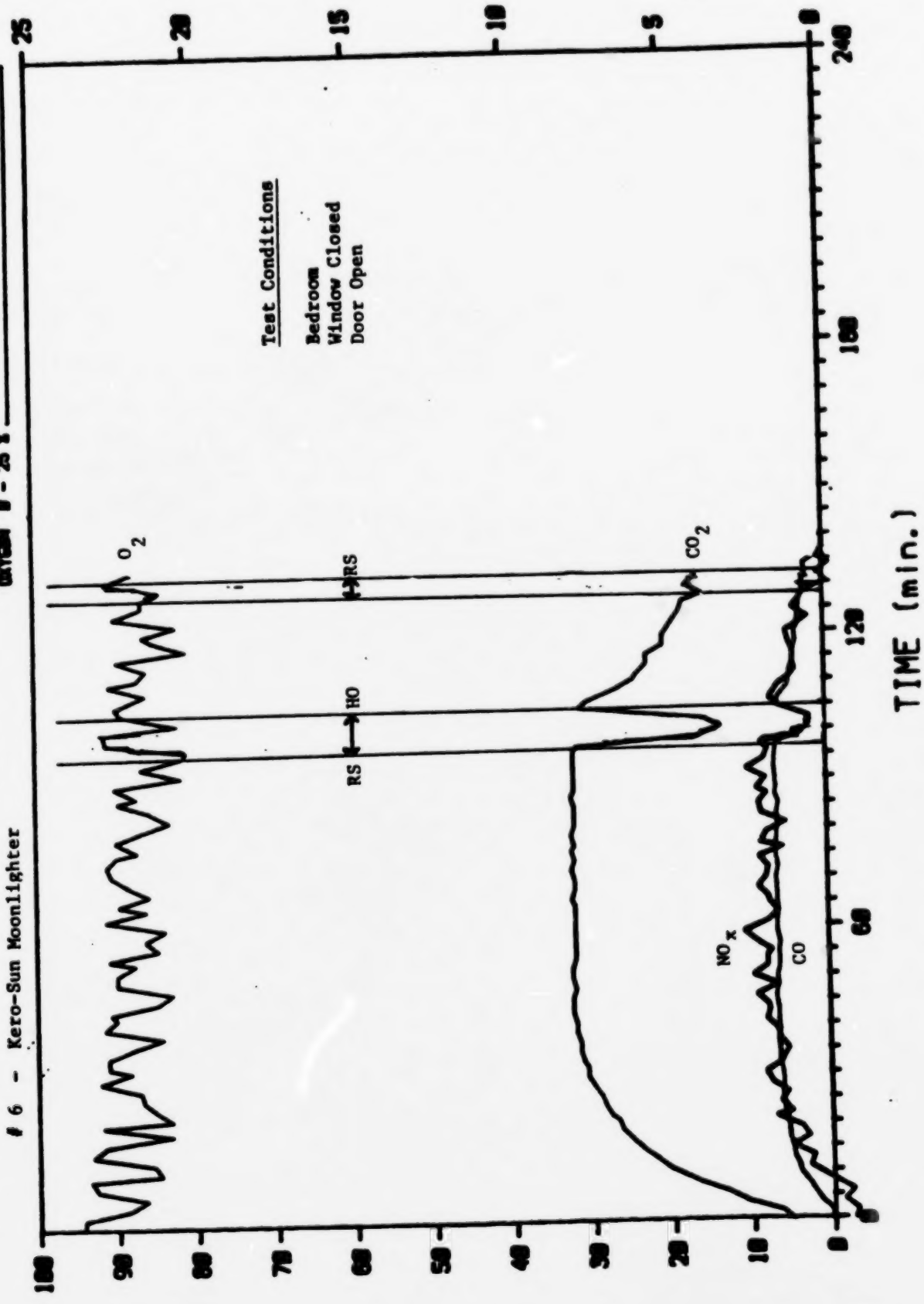


H6M8B.110

FIGURE 6

6 - Kero-Sun Moonlighter

WATER 0 - 20 ppm
CARBON MONOXIDE 0 - 100 ppm
CARBON DIOXIDE 0 - 2.5 %
OXYGEN 0 - 25 %



H11M5A.110

FIGURE 7

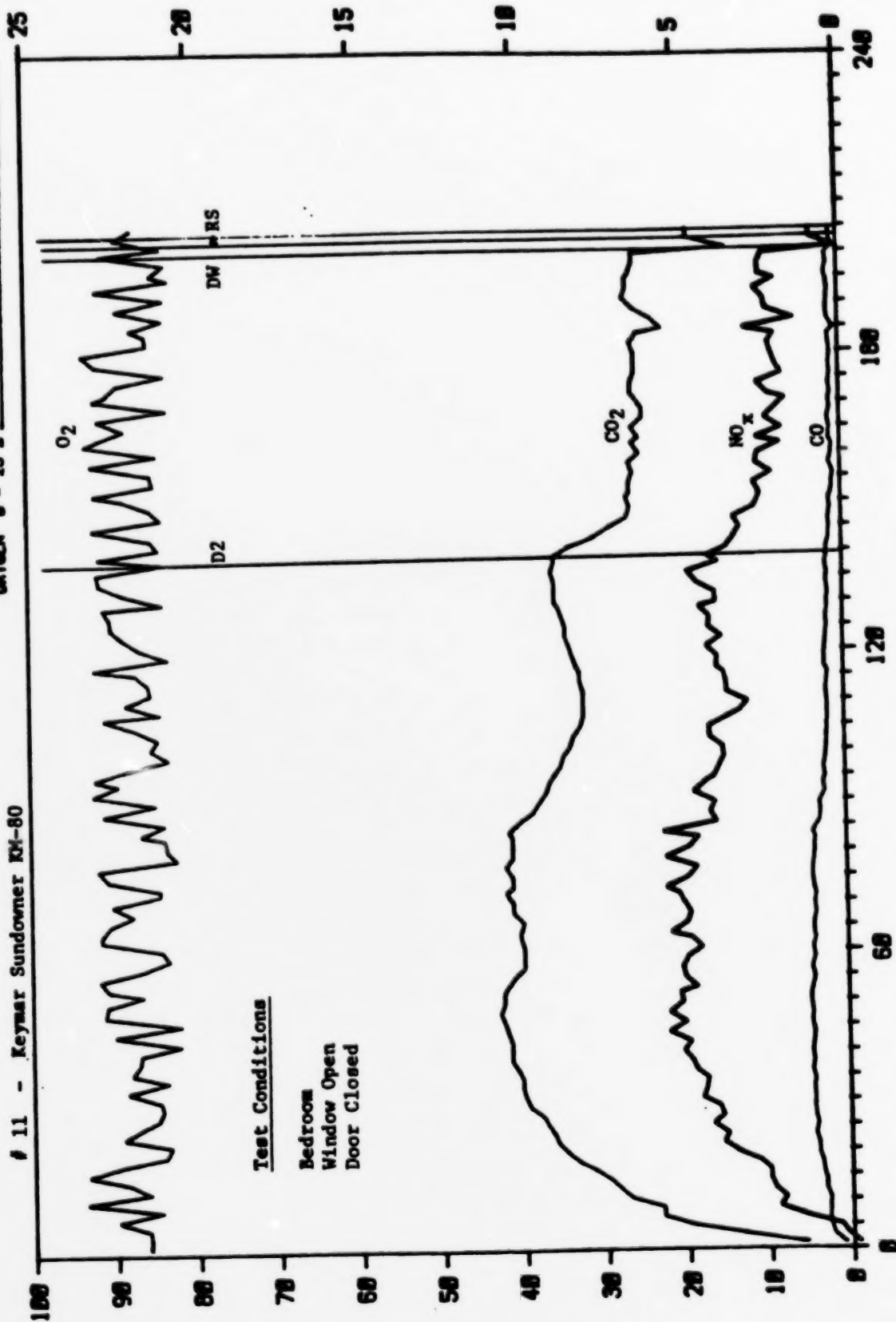
11 - Keymar Sundowner KM-80

WGA 0 - 10 ppm

CARBON MONOXIDE 0 - 100 ppm

CARBON DIOXIDE 0 - 2.5 %

OXYGEN 0 - 25 %



Test Conditions

Bedroom
Window Open
Door Closed

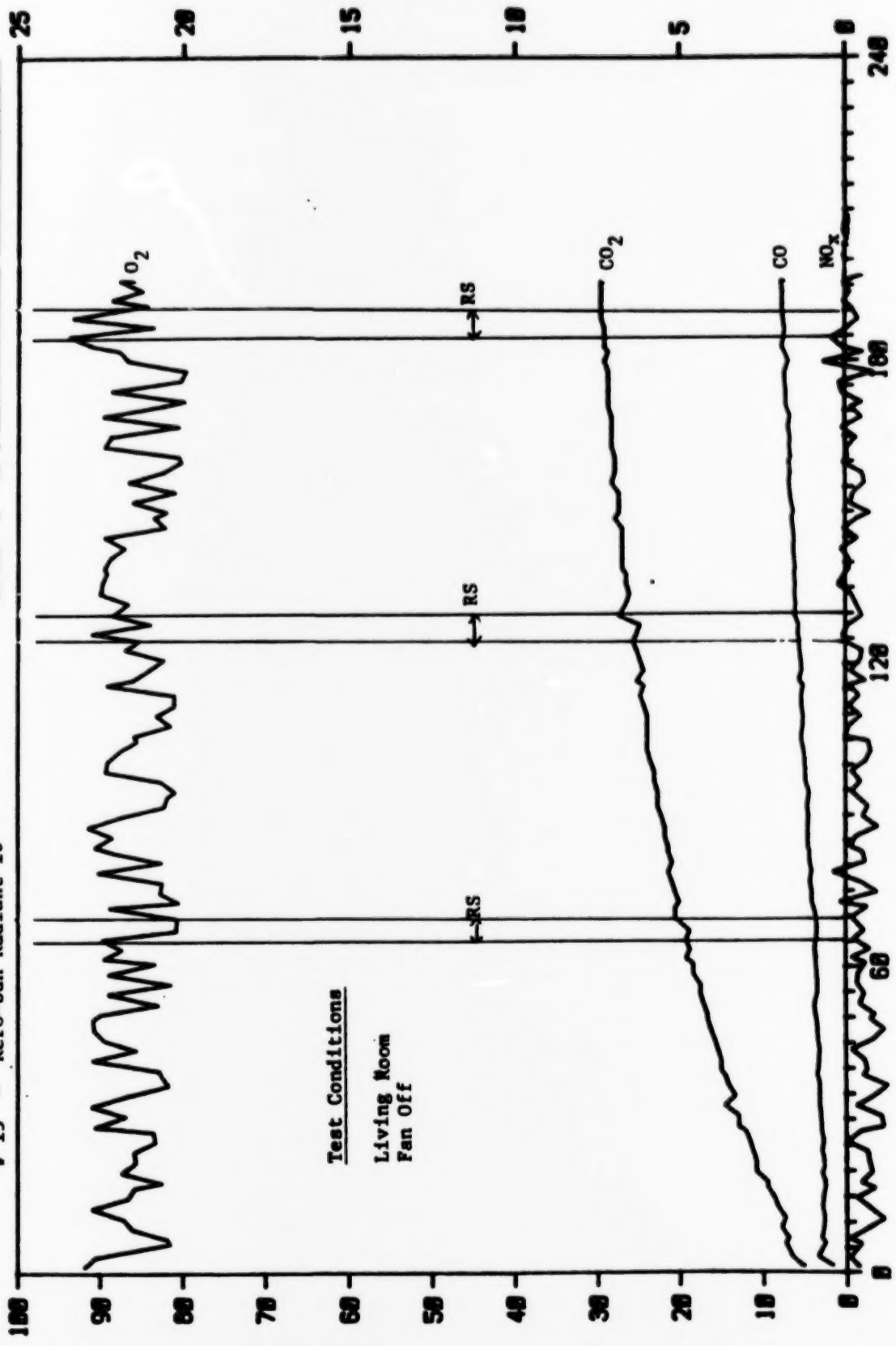
TIME (min.)

H15M13.110

FIGURE 8

15 - Kero-Sun Radiant 10

WATER 0 - 10 ppm
CARBON MONOXIDE 0 - 100 ppm
CARBON DIOXIDE 0 - 2.5 %
OXYGEN 0 - 25 %



Test Conditions

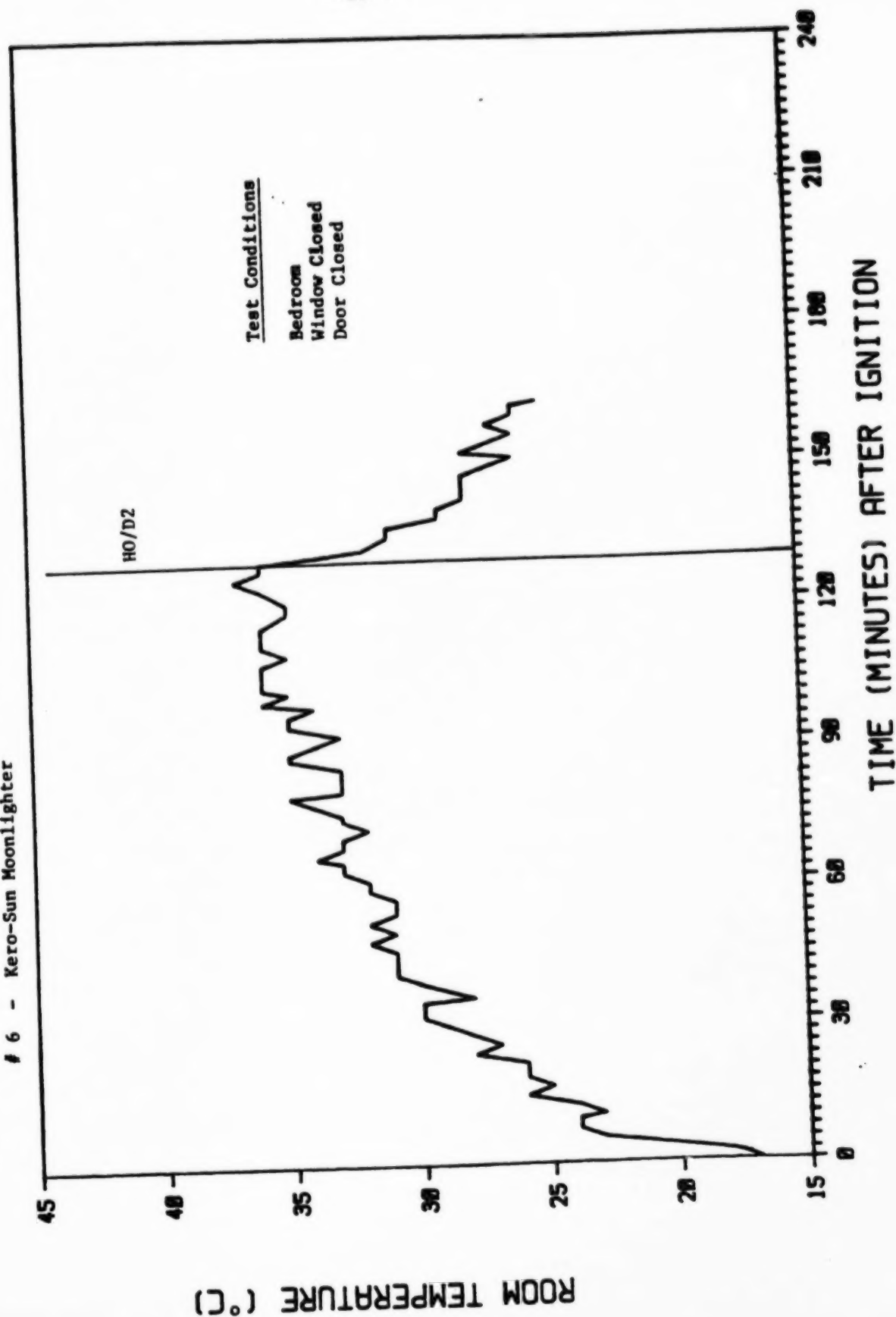
Living Room
Fan Off

TIME (min.)

H6M8C.110

6 - Kero-Sun Moonlighter

FIGURE 9



H6M8B.110

FIGURE 10

6 - Kero-Sun Moonlighter

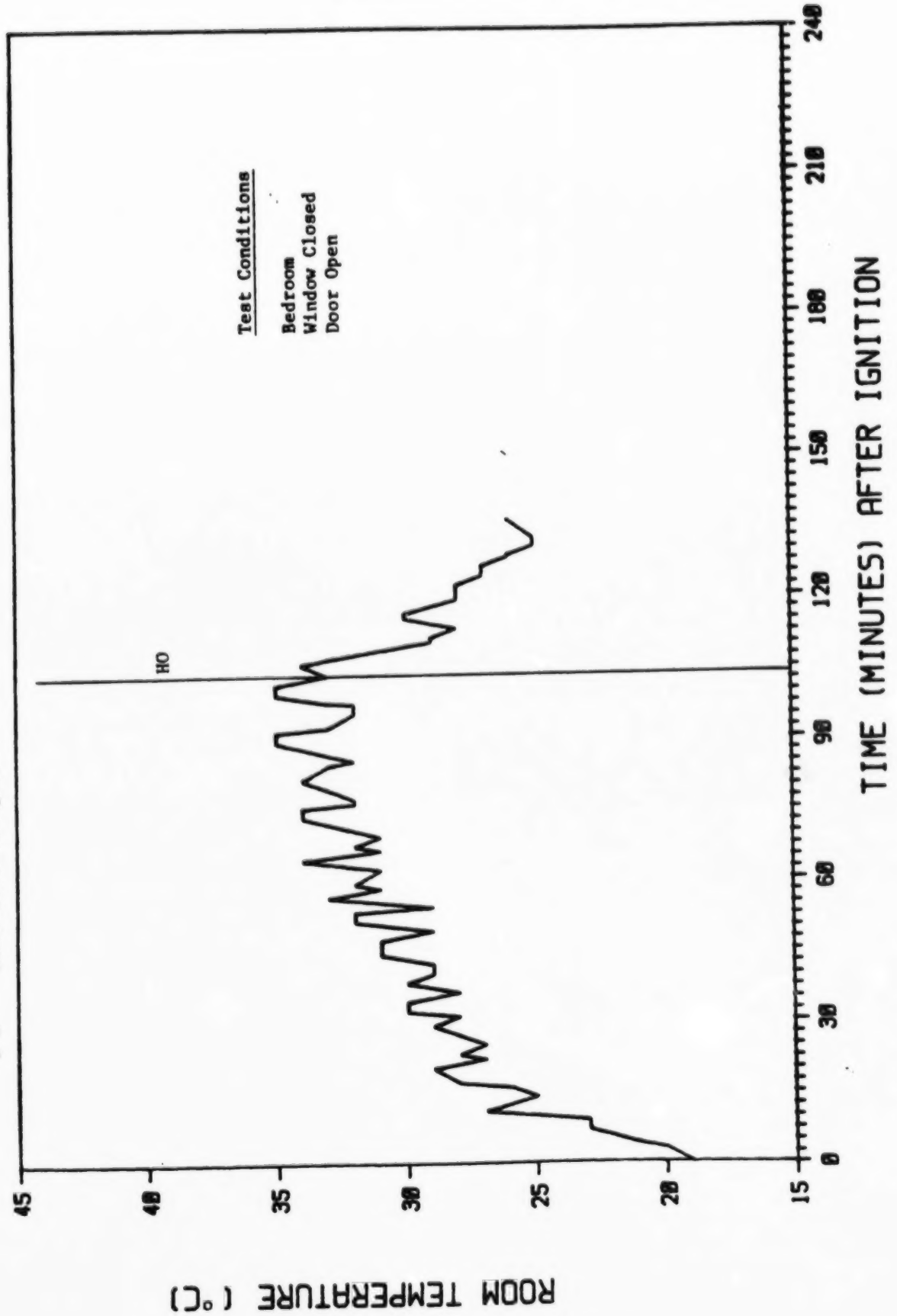


FIGURE 11

FUEL CONSUMPTION OF HEATER 7

- 1 x Bedroom: Window & Door closed
- 2 □ Bedroom: Window open 1" & Door closed
- 3 ○ Bedroom: Window closed & Door open 2"
- 4 ▲ Living Room: furnace fan off

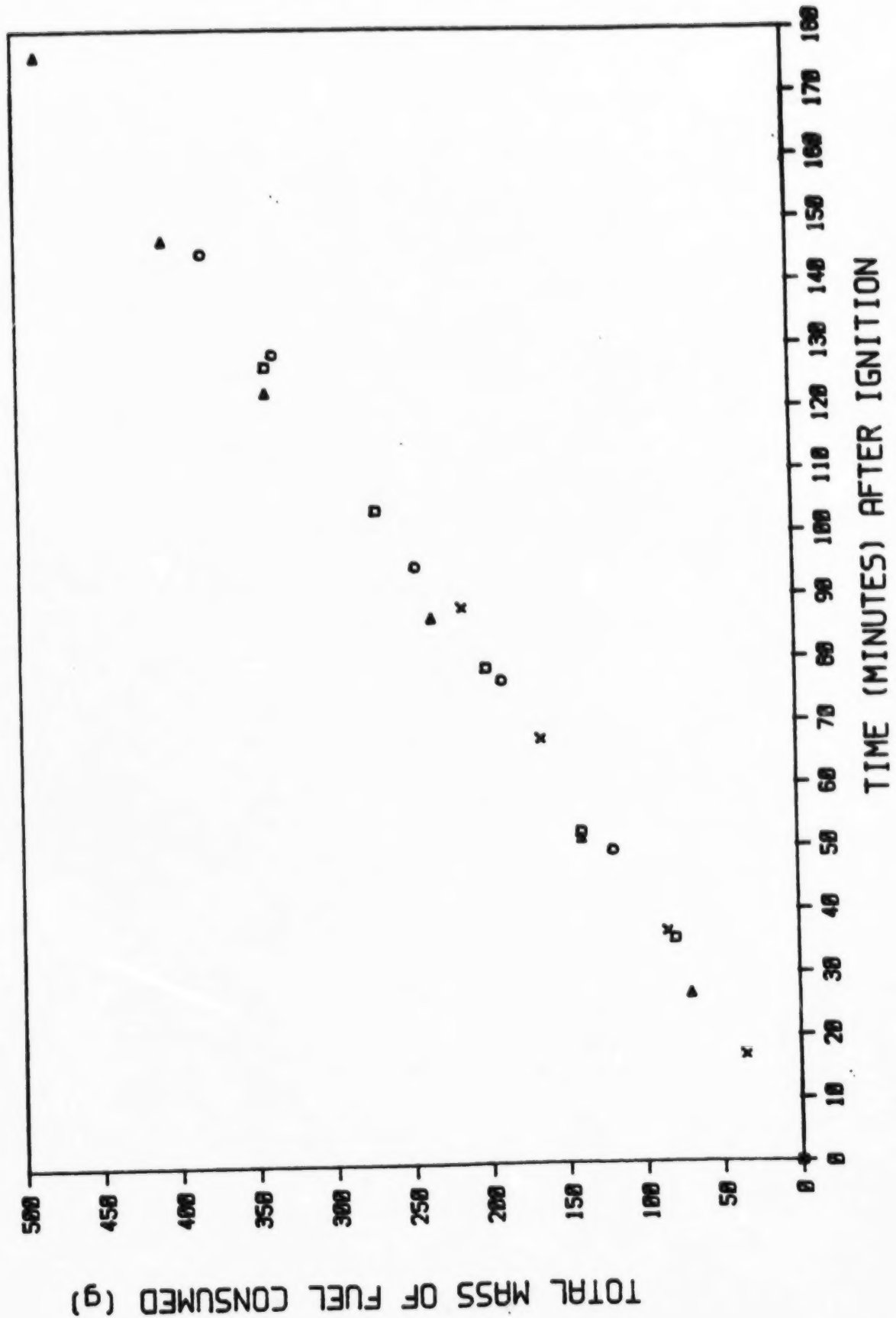


FIGURE 12

FUEL CONSUMPTION OF HEATER 11

- 1 X Bedroom: Window & Door closed
- 2 □ Bedroom: Window open 1" & Door closed
- 3 ○ Bedroom: Window closed & door open 2"
- 4 ▴ Living Room: Furnace fan off

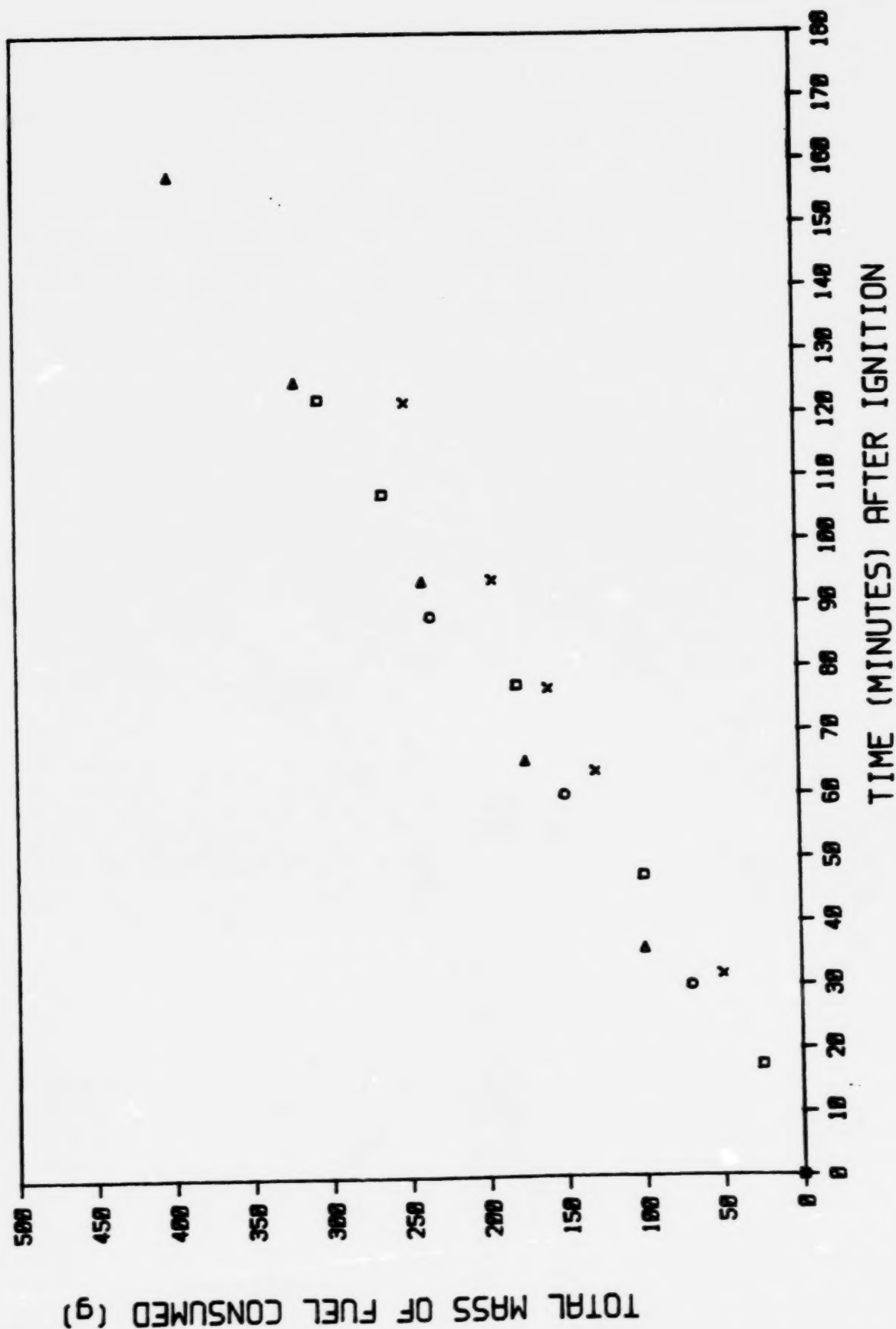


TABLE I(a) - Bedroom (Window & Door Closed) Gas Levels After
One Hour of Testing

Heater No. and Brand	Bedroom Temp.(°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temp. Range(°C)
1. Sunbeam OHRG28H	45	0.2	40.1	1.6	16 - 17
6. Kero-Sun Moonlighter	32	1.9	14.9	1.2	3 - 6
7. Kero-Sun Radiant 10	39	-	35.8	1.5	1 - 2
11. Keymar Sundowner KM-80	37	3.1	11.1	1.5	9 - 12
13. Kero-Sun Omni 85	49	2.1	3.9	1.9	12 - 13
14. Kero-Sun Radiant 8	41	0.8	17.7	1.6	8 - 9
15. Kero-Sun Radiant 10	41	0.4	17.6	1.7	6 - 7
16. Irwin Turco Heritage	62	5.7	3.1	2.1	2 - 3

* Corrected for initial background levels (see Table V)

- Indicates gas was not detected

TABLE I(b) - Bedroom (Window Open 2.5 cm & Door Closed) Gas Levels

Heater No. and Brand	Bedroom Temp. (°C)		NO _x * (ppm)		CO* (ppm)		CO ₂ * (%)		Outside Temp. Range (°C)
	1 h	2 h	1 h	2 h	1 h	2 h	1 h	2 h	
1. Sunbeam OHRC28R	39	42	-	-	13.9	9.9	0.7	0.6	7 - 11
6. Kero-Sun Moonlighter	30	32	1.0	1.0	6.7	5.8	0.7	0.7	3 - 11
7. Kero-Sun Radiant 10	31	37	0.1	0.2	7.7	8.3	0.5	0.5	4 - 5
11. Keymar Sundowner KM-80	37	41	1.8	1.7	3.2	1.3	0.8	0.7	9 - 11
13. Kero-Sun Omn1 85	45	55	1.5	1.4	1.0	1.0	1.1	1.1	6 - 9
14. Kero-Sun Radiant 8	37	40	0.1	0.1	7.4	7.1	0.6	0.6	6 - 7
15. Kero-Sun Radiant 10	40	45	0.2	0.4	7.4	7.4	0.9	0.8	6 - 11
16. Irwin Turco Heritage	45	N/A	1.9	N/A	0.5	N/A	0.9	N/A	1 - 3

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

N/A - Not available

TABLE I(c) - Bedroom (Window Closed & Door Open 5.0 cm) Gas Levels

Heater No. and Brand	Bedroom Temp. (°C)		NO _x * (ppm)		CO* (ppm)		CO ₂ * (%)		Outside Temp. Range (°C)
	1 h	1.5 h	1 h	1.5 h	1 h	1.5 h	1 h	1.5 h	
1. Sunbeam OHRG28H	32	32	-	0.1	9.3	12.1	0.4	0.5	11 - 14
6. Kero-Sun Moonlighter	32	36	1.3	1.0	5.9	5.9	0.6	0.6	6 - 12
7. Kero-Sun Radiant 10	34	38	0.2	-	9.7	11.8	0.7	0.7	1 - 2
11. Keymar Sundowner KT-80	38	41	1.5	1.5	2.0	2.2	0.7	0.8	10 - 12
13. Kero-Sun Omni 85	45	51	0.6	0.8	1.8	1.8	0.9	0.9	15 - 16
14. Kero-Sun Radiant 8	41	42	-	0.1	6.6	6.3	0.7	0.6	11 - 12
15. Kero-Sun Radiant 10	41	44	-	-	5.5	5.9	0.8	0.8	13 - 14
16. Irwin Turco Heritage	56	59	2.3	2.4	-	-	1.0	1.1	1 - 3

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

TABLE II - Living Room Gas Levels After
Three Hours of Testing

Heater No. and Brand	Temperature (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temp. Range(°C)
1. Sunbeam OHRG28H	26	-	9.1	0.5	4 - 5
6. Kero-Sun Moonlighter	26	-	3.7	0.3	5 - 6
7. Kero-Sun Radiant 10	27	-	10.4	0.5	3 - 5
11. Keymar Sundowner KM-80	27	0.5	2.4	0.5	3 - 7
13. Kero-Sun Omni 85	31	0.5	0.9	0.6	8 - 12
14. Kero-Sun Radiant 8	29	-	10.4	0.4	5 - 7
15. Kero-Sun Radiant 10	29	0.5	4.8	0.6	5 - 12
16. Irwin Turco Heritage	32	0.7	1.7	0.8	12 - 18

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

TABLE III - Gas Levels in Various Rooms During Living Room Tests

Heater No. and Brand	Hours After Ignition											
	ONE				TWO				THREE			
	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)
1. Sunbeam OHKG28H	25	-	4.0	0.3	26	0.1	6.8	0.4	26	-	9.1	0.5
(a) Living Room		-	5.2	0.3		-	7.8	0.5		0.3	10.6	0.5
(b) First Bedroom		-	5.0	0.4		0.2	8.1	0.5		0.4	10.6	0.5
(c) Second Bedroom		-	4.8	0.4		0.3	8.3	0.5		0.2	10.4	0.5
(d) Master Bedroom		-	4.7	0.4		0.2	7.9	0.5		0.2	10.5	0.5
(e) Kitchen												
6. Kero-Sun Moonlighter	25	-	1.9	0.1	26	-	2.8	0.2	26	-	3.7	0.3
(a) Living Room		-	1.6	0.1		-	2.8	0.2		0.2	3.3	0.2
(b) First Bedroom		-	1.2	0.1		-	2.1	0.2		-	2.8	0.2
(c) Second Bedroom		-	0.8	0.1		-	2.1	0.2		0.1	3.1	0.3
(d) Master Bedroom		-	1.3	0.1		0.1	2.4	0.2		-	3.0	0.3
(e) Kitchen												
7. Kero-Sun Radiant 10	26	-	3.3	0.3	26	-	7.2	0.4	27	0.2	10.4	0.5
(a) Living Room		-	4.1	0.3		-	8.0	0.4		-	10.7	0.5
(b) First Bedroom		-	3.9	0.3		-	7.7	0.4		-	10.6	0.5
(c) Second Bedroom		-	3.8	0.3		-	8.2	0.4		-	10.8	0.5
(d) Master Bedroom		-	4.5	0.3		-	8.4	0.4		-	12.0	0.5
(e) Kitchen												

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

TABLE III - Cont.

Heater No. and Brand	Hours After Ignition											
	ONE			TWO			THREE					
	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)
11. Keymar Sundowner												
KM-80	23	-	0.6	0.3	25	0.5	1.5	0.5	27	0.9	2.4	0.5
(a) Living Room		-	0.8	0.3		0.5	2.0	0.5		0.9	2.7	0.5
(b) First Bedroom		0.3	0.8	0.3		0.7	1.8	0.5		1.1	2.8	0.5
(c) Second Bedroom		0.1	0.7	0.4		0.4	1.8	0.5		1.1	2.4	0.6
(d) Master Bedroom		0.4	1.4	0.3		0.8	2.2	0.4		1.1	2.9	0.5
(e) Kitchen												
13. Kero-Sun												
Omni 85	28	0.2	0.1	0.4	30	0.6	0.8	0.6	31	0.5	0.9	0.6
(a) Living Room		0.3	-	0.3		0.4	0.3	0.5		0.6	0.5	0.6
(b) First Bedroom		0.1	-	0.3		0.3	0.3	0.5		0.4	0.7	0.6
(c) Second Bedroom		-	-	0.3		0.4	0.4	0.5		0.6	0.9	0.6
(d) Master Bedroom		0.6	0.2	0.4		0.6	0.7	0.6		0.6	1.2	0.7
(e) Kitchen												
14. Kero-Sun												
Radiant 8	28	-	3.3	0.3	29	-	7.1	0.4	29	-	10.4	0.4
(a) Living Room		-	4.2	0.3		-	7.9	0.4		-	11.5	0.5
(b) First Bedroom		-	4.0	0.3		-	7.5	0.4		-	11.3	0.5
(c) Second Bedroom		-	4.5	0.3		-	7.6	0.4		-	11.2	0.5
(d) Master Bedroom		-	4.4	0.4		0.1	8.1	0.4		-	11.7	0.5
(e) Kitchen												

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

TABLE III - Cont.

Heater No. and Brand	Hours After Ignition											
	ONE			TWO			THREE					
	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)
15. Kero-Sun Radiant 10												
(a) Living Room	26	-	1.8	0.3	28	0.2	3.6	0.5	29	0.5	4.8	0.6
(b) First Bedroom		-	2.3	0.4		0.1	4.1	0.5		0.2	5.7	0.6
(c) Second Bedroom		-	2.0	0.4		-	3.8	0.5		0.1	5.4	0.6
(d) Master Bedroom		-	1.7	0.3		0.2	3.7	0.5		-	5.4	0.6
(e) Kitchen		-	2.0	0.4		-	4.1	0.5		0.1	5.4	0.6
16. Irwin Turco Heritage												
(a) Living Room	30	0.1	0.6	0.5	31	0.6	1.3	0.7	32	0.7	1.7	0.8
(b) First Bedroom		0.2	0.6	0.5		0.5	1.3	0.7		1.0	1.5	0.9
(c) Second Bedroom		0.2	1.1	0.5		0.5	1.6	0.8		1.0	2.0	0.8
(d) Master Bedroom		-	0.8	0.5		0.5	1.2	0.8		0.8	1.8	0.9
(e) Kitchen		0.4	0.7	0.4		1.1	1.1	0.6		1.1	1.7	0.7

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

Outside
Temp. Range (°C)

5 - 12

Outside
Temp. Range (°C)

12 - 18

TABLE IV - Living Room Gas Levels After
Two Hours of Testing

Heater No. and Brand	FAN OFF					FAN ON				
	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temp. Range(°C)	Temp. (°C)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temp. Range(°C)
1. Sunbeam OHRG28H	26	0.1	6.8	0.4	4 - 5	25	0.1	8.2	0.3	5 - 6
6. Kero-Sun Moonlighter	26	-	2.8	0.2	5 - 6	24	0.1	2.6	0.3	3 - 6

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

TABLE V - Range of Background Gas Levels Measured Before The Experiments

Gas	Range
NO _x	0 - 0.8 ppm
CO	0.2 - 3.5 ppm
CO ₂	0.1 - 0.3%

TABLE VI - Test Room Gas Levels at 28°C

Heater No. and Brand	Room and Test Condition	Initial Room Temp. (°C)	Time to Reach 28°C (minutes)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temperature Range (°C)
1. Sunbeam OHRG28H	BR: WC/DC	24	5	-	5.5	0.3	16 - 17
	BR: WC/DO	21	13	-	6.2	0.2	11 - 14
	BR: WO/DC	22	8	-	6.7	0.3	7 - 11
	LR	21	(27°C @ 205)	0.1	10.2	0.5	4 - 5
6. Kero-Sun Moonlighter	BR: WC/DC	17	23	0.9	7.0	0.6	3 - 6
	BR: WC/DO	18	17	0.6	4.9	0.5	6 - 12
	BR: WO/DC	19	35	1.0	6.0	0.6	3 - 11
	LR	25	(27°C @ 188)	-	3.2	0.3	5 - 6
7. Kero-Sun Radiant 10	BR: WC/DC	18	12	0.1	8.6	0.4	1 - 2
	BR: WC/DO	14	17	0.2	9.1	0.6	1 - 2
	BR: WO/DC	14	32	-	9.1	0.5	4 - 5
	LR	22	173	-	10.3	0.5	3 - 5
11. Keyser Sundowner KH-80	BR: WC/DC	17	16	0.7	4.9	0.6	9 - 12
	BR: WC/DO	19	6	0.6	1.7	0.4	10 - 12
	BR: WO/DC	19	11	0.9	1.7	0.5	9 - 11
	LR	20	(26°C @ 195)	0.9	2.5	0.5	3 - 7

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

BR bedroom; WC window closed; DC door closed

DO door open; WO window open; LR living room

TABLE VI - Cont.

Heater No. and Brand	Room and Test Condition	Initial Room Temp. (°C)	Time to Reach 28°C (minutes)	NO _x * (ppm)	CO* (ppm)	CO ₂ * (%)	Outside Temperature Range (°C)
13. Kero-Sun Omni 85	BR: WC/DC	26	2	-	0.3	0.1	12 - 13
	BR: WC/DO	25	4	-	2.7	0.1	15 - 16
	BR: WO/DC	22	7	-	2.1	0.3	6 - 9
	LR	25	40	-	-	0.3	8 - 12
14. Kero-Sun Radiant 8	BR: WC/DC	22	8	-	7.4	0.4	8 - 9
	BR: WC/DO	24	8	0.3	7.7	0.3	11 - 12
	BR: WO/DC	20	10	0.2	6.4	0.4	6 - 7
	LR	24	40	-	2.2	0.2	5 - 7
15. Kero-Sun Radiant 10	BR: WC/DC	18	9	-	6.6	0.6	6 - 7
	BR: WC/DO	20	8	-	4.4	0.4	13 - 14
	BR: WO/DC	18	12	-	5.7	0.5	6 - 11
	LR	23	113	-	3.4	0.5	5 - 12
16. Irwin Turco Heritage	BR: WC/DC	22	2	-	1.1	0.2	2 - 3
	BR: WC/DO	22	1	-	0.9	0.2	1 - 3
	BR: WO/DC	17	5	0.3	1.7	0.4	1 - 3
	LR	26	16	-	0.4	0.2	12 - 18

* Corrected for initial background levels (See Table V)

- Indicates gas was not detected

BR bedroom; WC window closed; DC door closed

DO door open; WO window open; LR living room

TABLE VII (a) - Fuel Consumption Data
Heater No. and Brand: # 1 - Sunbeam OHRG28H

Bedroom: Window and Door Closed			Bedroom: Window Open 2.5 cm and Door Closed			Bedroom: Window Closed and Door Open 5.0 cm			Living Room		
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (sec)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)
0	15.075	0	0	14.745	0	0	14.620	0	0	13.480	0
125.3	14.785	290	38.1	14.635	110	31.0	14.535	85	37.7	13.370	110
			54.9	14.600	145	60.5	14.450	170	68.0	13.280	200
			66.9	14.555	190	89.4	14.375	245	98.2	13.195	285
			97.5	14.475	270	119.4	14.290	330	129.5	13.105	375
			113.0	14.430	315	149.5	14.215	405	160.8	13.020	460
									189.2	12.940	540
Average Fuel Consumption Rate: 139 g/h			Average Fuel Consumption Rate: 167 g/h			Average Fuel Consumption Rate: 163 g/h			Average Fuel Consumption Rate: 171 g/h		

TABLE VII (b) - Fuel Consumption Data
Heater No. and Brand: # 6 - Kero-Sun Moonlighter

Bedroom: Window and Door Closed			Bedroom: Window Open 2.5 cm and Door Closed			Bedroom: Window Closed and Door Open 5.0 cm			Living Room		
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)
0	9.190	0	0	9.135	0	0	9.380	0	0	8.620	0
11.9	9.175	15	34.1	9.080	55	32.6	9.325	55	27.8	8.575	45
41.9	9.125	65	76.1	9.025	110	62.6	9.275	105	57.8	8.520	100
56.9	9.100	90	94.1	8.965	170	92.6	9.220	160	88.1	8.465	155
71.9	9.075	115	124.1	8.910	225				126.6	8.390	230
86.9	9.055	135							148.0	8.355	265
101.9	9.030	160							177.0	8.305	315
121.9	9.000	190									
Average Fuel Consumption Rate: 94 g/h			Average Fuel Consumption Rate: 109 g/h			Average Fuel Consumption Rate: 104 g/h			Average Fuel Consumption Rate: 106 g/h		

TABLE VII (c) - Fuel Consumption Data
Heater No. and Brand: # 7 - Kero-Sun Radiant 10

Bedroom: Window and Door Closed				Bedroom: Window Open 2.5 cm and Door Closed				Bedroom: Window Closed and Door Open 5.0 cm				Living Room			
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	
0	15.615	0	0	15.525	0	0	15.050	0	0	15.905	0	0	15.905	0	
16.8	15.580	35	35.5	15.445	80	49.5	14.930	120	26.6	15.835	70	26.6	15.835	70	
36.6	15.530	85	52.5	15.385	140	76.5	14.860	190	51.4	15.765	140	51.4	15.765	140	
67.3	15.450	165	78.5	15.325	200	94.5	14.805	245	86.4	15.670	235	86.4	15.670	235	
88.0	15.400	215	103.5	15.255	270	128.5	14.715	335	122.4	15.565	340	122.4	15.565	405	
			126.5	15.185	340	144.5	14.670	380	146.6	15.500	485	146.6	15.500	485	
Average Fuel Consumption Rate: 146 g/h			Average Fuel Consumption Rate: 161 g/h			Average Fuel Consumption Rate: 158 g/h			Average Fuel Consumption Rate: 165 g/h						

TABLE VII (d) - Fuel Consumption Data

Heater No. and Brand: # 11 - Keymar Sundowner KM-80

Bedroom: Window and Door Closed				Bedroom: Window Open 2.5 cm and Door Closed				Bedroom: Window Closed and Door Open 5.0 cm				Living Room			
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	
0	10.505	0		0	11.445	0		0	10.765	0		0	7.705	0	
31.7	10.455	50		17.3	11.420	25		30.0	10.695	70		35.8	7.605	100	
63.7	10.375	130		47.3	11.345	100		60.0	10.615	150		65.3	7.530	175	
76.7	10.345	160		77.3	11.265	180		88.0	10.530	235		93.5	7.465	240	
93.7	10.310	195		107.3	11.180	265						125.0	7.385	320	
121.7	10.255	250		122.3	11.140	305						157.8	7.305	400	
Average Fuel Consumption Rate: 123 g/h				Average Fuel Consumption Rate: 150 g/h				Average Fuel Consumption Rate: 160 g/h				Average Fuel Consumption Rate: 152 g/h			

TABLE VII (e) - Fuel Consumption Data
Heater No. and Brand: # 13 - Kero-Sun Omni 85

Bedroom: Window and Door Closed				Bedroom: Window Open 2.5 cm and Door Closed				Bedroom: Window Closed and Door Open 5.0 cm				Living Room		
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)
0	10.805	0		0	11.950	0		0	11.570	0		0	12.570	0
37.2	10.690	115		34.4	11.820	130		21.3	11.495	75		28.0	12.455	115
52.2	10.640	165		64.2	11.690	260		51.3	11.380	190		55.3	12.330	240
67.2	10.590	215		92.3	11.580	370		81.3	11.270	300		115.7	12.055	515
				122.3	11.450	500						146.8	11.915	655
Average Fuel Consumption Rate: 192 g/h				Average Fuel Consumption Rate: 245 g/h				Average Fuel Consumption Rate: 221 g/h				Average Fuel Consumption Rate: 268 g/h		

TABLE VII (f) - Fuel Consumption Data
Heater No. and Brand: # 14 - Kero-Sun Radiant 8

Bedroom: Window and Door Closed				Bedroom: Window Open 2.5 cm and Door Closed				Bedroom: Window Closed and Door Open 5.0 cm				Living Room			
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)		Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	
0	11.475	0		0	11.820	0		0	11.415	0		0	12.215	0	
35.6	11.390	85		18.2	11.780	40		26.2	11.350	65		32.1	12.125	90	
65.6	11.320	155		31.0	11.730	90		52.2	11.280	135		62.1	12.035	180	
				49.3	11.690	130		81.6	11.195	220		70.6	12.025	190	
				79.0	11.615	205						92.1	11.965	250	
				108.0	11.530	290						122.1	11.895	320	
												152.1	11.815	400	
Average Fuel Consumption Rate: 142 g/h				Average Fuel Consumption Rate: 161 g/h				Average Fuel Consumption Rate: 162 g/h				Average Fuel Consumption Rate: 158 g/h			

TABLE VII (g) - Fuel Consumption Data
Heater No. and Brand: # 15 - Kero-Sun Radiant 10

Bedroom: Window and Door Closed			Bedroom: Window Open 2.5 cm and Door Closed			Bedroom: Window Closed and Door Open 5.0 cm			Living Room		
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)
0	12.880	0	0	12.615	0	0	11.980	0	0	13.710	0
9.3	12.850	30	29.1	12.515	100	33.2	11.875	105	34.4	13.600	110
24.3	12.810	70	56.7	12.425	190	62.6	11.775	205	64.0	13.510	200
39.1	12.760	120	86.9	12.330	285	92.6	11.680	300	94.0	13.410	300
69.3	12.670	210	116.5	12.225	390				124.0	13.320	390
									154.0	13.230	480
									184.0	13.140	570
Average Fuel Consumption Rate: 182 g/h			Average Fuel Consumption Rate: 201 g/h			Average Fuel Consumption Rate: 194 g/h			Average Fuel Consumption Rate: 186 g/h		

TABLE VII (h) - Fuel Consumption Data
Heater No. and Brand: # 16 - Irwin Turco Heritage No. 31050

Bedroom: Window and Door Closed			Bedroom: Window Open 2.5 cm and Door Closed			Bedroom: Window Closed and Door Open 5.0 cm			Living Room		
Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)	Time After Ignition (min)	Heater Weight (kg)	Total Weight of Fuel Consumed (g)
0	14.340	0	0	15.700	0	0	14.980	0	0	14.085	0
11.7	14.260	80	24.1	15.540	160	17.4	14.865	115	17.7	13.970	115
21.7	14.205	135	30.1	15.495	205	34.4	14.755	225	31.2	13.900	185
31.7	14.155	185	40.1	15.430	270	50.8	14.650	330	95.0	13.570	515
41.7	14.100	240	50.1	15.370	330	79.9	14.555	425	120.7	13.445	640
51.7	14.055	285	60.8	15.305	395	93.0	14.465	515	150.7	13.290	795
61.7	14.010	330					14.395	585	180.7	13.150	935
Average Fuel Consumption Rate: 321 g/h			Average Fuel Consumption Rate: 390 g/h			Average Fuel Consumption Rate: 378 g/h			Average Fuel Consumption Rate: 311 g/h		

TABLE VIII - Kerosene Fuel Analysis*

1. PE 240 Elemental Analyzer	
Carbon, weight %	85.49
Hydrogen, weight %	13.61
2. Nitrogen, ppm by weight	2.2
(Dohrmann Chemiluminescence)	
3. Sulphur, ppm by weight	83
(Wickbold Technique)	
4. Ash, weight %	0.002

* Petroleum and Gas Laboratories, CANMET,
Energy, Mines and Resources Canada.

TABLE IX(a) - Maximum Experimental Temperatures
(Bedroom - Window & Door Closed)

Heater No. and Brand	Room Temperature* (°C)	Heater Top Temperature (°C)	Heater Front Temperature (°C)	Outside Temp. Range (°C)
1. Sunbeam OHRG28H	49 (107)	274	59	16 - 17
6. Kero-Sun Moonlighter	36 (95)	229	37	3 - 4
7. Kero-Sun Radiant 10	42 (80)	211	46	1 - 2
11. Keymar Sundowner KM-80	43 (112)	293	57	8 - 10
13. Kero-Sun Omni 85	59 (111)	327	57	11 - 13
14. Kero-Sun Radiant 8	49 (149)	268	71	8 - 9
15. Kero-Sun Radiant 10	46 (85)	259	87	6 - 7
16. Irwin Turco Heritage	62 (57)	319	55	2

* Number in brackets indicates time (minutes) after ignition at which maximum room temperature was attained

TABLE IX(b) - Maximum Experimental Temperatures
(Bedroom - Window Open 2.5 cm & Door Closed)

Heater No. and Brand	Room Temperature* (°C)	Heater Top Temperature (°C)	Heater Front Temperature (°C)	Outside Temp. Range (°C)
1. Sunbeam OHRG28H	44 (180)	264	64	7 - 11
6. Kero-Sun Moonlighter	34 (123)	243	33	3 - 12
7. Kero-Sun Radiant 10	37 (115)	207	46	3 - 5
11. Keymar Sundowner KM-80	43 (115)	328	65	6 - 14
13. Kero-Sun Omni 85	57 (137)	370	49	6 - 9
14. Kero-Sun Radiant 8	43 (146)	281	71	6 - 8
15. Kero-Sun Radiant 10	47 (115)	256	81	6 - 11
16. Irwin Turco Heritage	54 (89)	352	41	1 - 3

* Number in brackets indicates time (minutes) after ignition at which maximum room temperature was attained

TABLE IX(c) - Maximum Experimental Temperatures
(Bedroom - Window Closed & Door Open 5.0 cm)

Heater No. and Brand	Room Temperature* (°C)	Heater Top Temperature (°C)	Heater Front Temperature (°C)	Outside Temp. Range (°C)
1. Sunbeam OHRG28H	36 (121)	233	49	11 - 14
6. Kero-Sun Moonlighter	36 (89)	244	33	6 - 11
7. Kero-Sun Radiant 10	41 (140)	208	47	2 - 4
11. Keymar Sundowner KM-80	42 (87)	323	62	10 - 12
13. Kero-Sun Omni 85	55 (177)	338	45	15 - 16
14. Kero-Sun Radiant 8	43 (95)	271	69	12
15. Kero-Sun Radiant 10	45 (93)	254	72	13 - 14
16. Irwin Turco Heritage	61 (93)	342	47	2

* Number in brackets indicates time (minutes) after ignition at which maximum room temperature was attained

TABLE IX(d) - Maximum Experimental Temperatures
(Living Room)

Heater No. and Brand	Room Temperature* (°C)	Heater Top Temperature (°C)	Heater Front Temperature (°C)	Outside Temp. Range (°C)
1. Sunbeam OHRG28H	27 (166)	247	60	4 - 5
6. Kero-Sun Moonlighter	27 (137)	246	35	5 - 6
7. Kero-Sun Radiant 10	28 (173)	211	63	3 - 5
11. Keymar Sundowner KM-80	27 (180)	350	55	3 - 7
13. Kero-Sun Omni 85	31 (150)	N/A	39	8 - 12
14. Kero-Sun Radiant 8	29 (71)	270	76	5 - 7
15. Kero-Sun Radiant 10	29 (173)	N/A	78	5 - 12
16. Irwin Turco Heritage	33 (166)	299	37	12 - 18

* Number in brackets indicates time (minutes) after ignition at which maximum room temperature was attained

N/A - Not available

Appendix A

Kerosene Heaters Testing At Orleans

No.	Brand/Model	Btu per hour	Type
1	Sunbeam OHRG28H*	9000	Radiant
6	Kero-Sun Moonlighter*	8700	Convective
7	Kero-Sun Radiant 10*	10 000	Radiant
11	Keymar Sundowner KM-80*	8500	Convective
13	Kero-Sun Omni 85	13 000	Convective
14	Kero-Sun Radiant 8	8200	Radiant
15	Kero-Sun Radiant 10	10 000	Radiant
16	Irwin Turco Heritage No. 31050	19 800	Convective

* Previously tested at Consumers' Association of Canada

